Chapter 10
Research and Development

Large-scale production of wood pellets started in Germany in 2001. As far as the author knows, the first industrial plant for producing wood pellets in Germany was that by the Westwälder Holzpellets GmbH in Langenbach in the Westerwald forest. It was erected on the initiative of the partner and managing director Markus Mann on company premises next to a combined biomass heat and power plant, the heat of which was used for drying the chips.

In this chapter, technical aspects and biomass potentials will be discussed. It is worth mentioning, therefore, that the development in the fields of marketing and education began in this plant. Training courses en masse for heating companies, chimney sweeps, presentations etc. as carried out in those days by the company are no longer needed today and are, therefore, no longer a part of the subject of development. Nevertheless, this pioneering spirit has been a decisive influence on the speed of the proliferation of the use of wood pellets as an energy source.

The evolution and improvement of the efficiency of pellet boilers is progressing enormously. These highly developed boilers with their excellent efficiency make correspondingly high demands on the fuel. The situation in Germany, Austria, Italy etc. cannot be compared with e.g. the Scandinavian market where wood pellets were used long before the first pellet producer began operations in Germany. The pellet boilers are of such rugged quality that the demand for pellet quality is low compared with the German market.

Knowledge of the following basic parameters represents an essential basis for the production of high-quality wood pellets. Firstly, the pelletizer must know the characteristic properties of the raw material so that he can appropriately adjust the individual process components for preparing the raw material. On the other hand, the quality requirements of the final product or of the consumer, respectively, determine the necessary conditioning measures and press parameters during the production process (e.g. the use of binding agents, dimensions of the wood pellets). Lastly, however, fuel handling and fuel conditions (moisture, storage time etc.) during pellet transportation and storage and the structural design and operability of the heating system itself also influence the successful use of the fuel.

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In practice, the interaction of these various types of components represents a great challenge since several partially competing elements acting within the fuel supply chain can influence the pellet quality and the (further) development of optimized heating systems is based on standardized fuel characteristics.

Although the industry is increasingly aware of the need for providing a closed fuel quality assurance system for the ultimate customer, one or the other damage case shows that there is a further need for research and qualification and optimization measures in the pellet production, the fuel and heating system standardisation, the provision of verifiable measuring and testing methods, the pellet storage and the reduction of the emission of pollutants from the combustion. Some of the most important "construction sites" will be described below.

10.1 Optimizing the Pellet Production

Wood pellets are currently being produced largely from woody biomass, only a small proportion of which consists of bark, independently of whether the pellets are intended for the premium pellet market or for the industrial pellet market. In particular, bark is separated from the raw material before pelletization since the dies cannot withstand the abrasiveness of the bark and the production costs, therefore, become uneconomical due to the increased wear. Considering the limited availability of high-quality technical raw material potentials for pellet production, appropriate direction of the flow of material within the pellet market appears to be increasingly necessary in order to be able to service both the efficient use of wood pellets in the small consumer market and the growing demand for industrial pellets for the power station sector. The flow of material can be controlled both politically (e.g. raw material restrictions or stimuli for using alternative biomasses for power stations as in the UK or Poland) and financially (e.g. distinct price difference between agropellets and premium wood pellets. However, it must be actively supported by the pelletizers and fuel dealers in order to inform potential customers professionally about the advantages and disadvantages of different pellet qualities.

In future, the flexible production of pellets of different raw material and end product qualities will require planners, plant manufacturers and pelletizers to have much more extensive knowledge of the characterizing properties of the raw materials and the inclusion of binding agents or additives in the pelletizing process. This should also include consideration of the admixture of liquid additives and additives dissolved in steam which can contribute both to the enhancement of the fuel quality and to the optimization of the process. In addition, the enzymatic extraction of the biogenic raw material for activating new bridge linkages offers an additional option for developing the pelletization process further. However, using novel raw material processing and conditioning measures requires the provision of technical plant components which, e.g. guarantee as homogeneous as possible an admixture of alternative additives (apart from powdery pressing aids) and cause minimal wear and maintenance breaks even in the case where partly harder raw materials are used (hardwoods).

Similarly, the selective mixing of different qualities of raw materials may present a possibility for compensating for unfavourable pelletizing and combustion characteristics in the medium term and at the same time enable new cost-effective and/or regional raw material potentials to be tapped.

The continuous analysis and evaluation of cost saving potentials during the pellet production can also contribute to a lowering and securing of as constant as possible a pellet price level. The planning of new pellet plants should include especially the use of sustainable, preferably regional occurrences of raw materials. The individual concept of the site with it dimensions and long-term existence must always be considered also as a contribution to the regional creation of value.

The following key aspects of research and development are thus of relevance to the optimisation of the pellet production process in the short to medium term:

- Characterisation of the properties of biogenic raw materials for pelletization, including agricultural and forestry-related biomass and industrial remnants, storage conditions and aging processes.
- Determination of the world-wide potential of raw materials also in developing countries and evaluation of the logistics concepts for tapping the markets for raw materials,
- Provision of effective and most flexible raw material processing methods possible for milling and drying stalk-type material and biomass from fruits for the pellet production.
- Investigations relating to the admixture of additives for optimising the physical/mechanical fuel characteristics of non-wood pellets or mixed pellets (e.g. for increasing the fuel durability) and for compensating for adverse chemical/material fuel characteristics (e.g. for reducing particle emissions or for improving the ash fusibility),
- Improvement of the technical possibilities for admixing binding agents and aggregates; optimisation of the conditioning parameters such as the use of water/steam, time and energy expenditure).
- Method-related development of the pressing method, taking into consideration the most flexible raw-material-specific adaptations possible (reduction of the energy used, minimizing the maintenance and repair times/costs, optimisation of dies and edge runner design, more wear-resistant materials).
- Analysis and description of variable fuel characteristics during pellet storage and transportation.
- Optimisation of the measuring methods and test standards for fuel-specific analysis, verifiability of the examination results.
- Development of the product standards and quality assurance measures for wood and non-wood pellets according to application technology and performance class.

10.2 Optimizing the Capacity of Wood Pellets for Their Use as an Energy Source

In parallel with the optimization and further development of the pellet production, technical maturation of the combustion systems is required which—in spite of the necessity for large cost reductions in the manufacture of the plant in order to increase competitiveness in comparison with fossil heating systems—guarantee the use of pellets having higher pollutant contents in the ashes and in the emission. Using corrosion-resistant materials, air- or water-cooled grids and inexpensive secondary measures for reducing pollutants in the exhaust gases are already being developed. Process = optimized control elements which can control both the fuel supply and the air supply in the combustion space individually and automatically should also be developed further. This also includes, for instance, the standardized installation of long-lasting lambda probes in small heating systems, synchronization of the fuel delivery into the combustion space in accordance with the current load requirement profile (heat requirement), the fuel temperature and waste gas emissions (CO/TOC content) and the total effectiveness of the combustion system (efficiency). Furthermore, standardization of the structural design of the fuel supply (including fuel screws) in the pellet boilers/furnaces and of the combustion chamber could entail an increasing homogenization of the pellet qualities.

However, various investigations conducted in practice have also shown that, apart from the pellet combustion site, hydraulic linkage of the plant into the existing line network also offers great potentials for optimization. In addition, it is possible to achieve a reduction of partial-load states by installing buffer stores and combining the pellet heating system with a solar heating-type tap water heater.

On the exhaust gas side, the installation of baffles in the flue is extended further. The emission of particulate matter by pellet plants are already being analyzed today in several research projects (e.g. at the TFZ. The Hamburg–Harburg TU and the DBFZ) with regard to their origin composition and mechanism of action on humans. It is expected that the current scientific studies and continuing practical investigations will result in pointing to effective measures for avoiding or reducing the presence of particulate matter.

Apart from the research activities already being conducted, there is a further need for optimizing the possible applications of pellets as energy sources with regard to

- Fuel supply and ash removal into and out of the combustion chamber, respectively,
- Combustion chamber design of the boiler and furnace for optimizing the fuel burnout, the reduction of pollutant emissions and the effective heat transfer
- The availability of small and medium-sized heating systems licensable in DE for using stalk-type or mixed pellets (wood pus stalks or other biomass)
- Provision of effective particle separators

- Optimization of the annual efficiency of the heating system including heat insulation and recovery measures and of the combination of pellet and solar systems
- Lowering the production costs of the heating system and of the technical plant components for fuel conveyance and waste gas conditioning
- Using pellets in plants for coupled power and heat generation (e.g. Stirling plants)
- Fixing sustainability criteria for assessing the use of pellets for providing energy
- Torrefaction/carbonization of various biomasses with subsequent pelletization for use in coal-fired power stations.

Against the background of the above-mentioned numerous research aspects it remains to be hoped that the optimization of the pellet energy source will advance further in the coming years and the research funds needed for this will be provided in sufficient amounts by industry, small and medium-sized businesses and the public authorities. As long as the economic competitiveness of pellets for generating power and heat cannot be secured compared with fossil fuels it will be the political and legal framework (e.g. target quotas for using biomass or the arrangement of the Renewable Energy Law or of the Renewable Energy Heat Law) which determines the growth of the national and international markets. For the players in the industry and for potential investors, this means that any greater utilization of the existing pellet production capacities is possible only with a framework with long-term stability and incentive programs and the current pellet production quantities will continue to be available as substitutes for fossil fuels. However, the medium- and long-term development of the pellet market will also urgently require, apart from stable framework conditions, the mobilization of additional raw material potentials (e.g. the use of forest wood off-cuts, energy plants, straw) for safeguarding the production capacities.